

Listed below is a clean copy of new and amended claims. A marked-up copy of the amended claims is provided in an accompanying document.

Subf1 531. (amended) A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from heaters to at least a portion of the formation;
allowing the heat to transfer from the heaters to a part of the formation, wherein superposition of heat from at least two of the heaters pyrolyzes some hydrocarbons in the part of the formation;
controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute; and
producing a mixture from the formation.

Subf1 539. (amended) The method of claim 531, wherein providing heat from the heaters to at least the portion of the formation comprises:

E2 heating a selected volume (V) of the hydrocarbon containing formation from the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (P_{wr}) provided to the selected volume is equal to or less than $h \cdot V \cdot C_v \cdot \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

Subf1 541. (amended) The method of claim 531, wherein allowing heat to transfer from the heaters increases a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

E4 5441. (new) A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer from the one or more heaters to a part of the formation;

controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute, and wherein an average heating rate of the part of the formation is less than about 1 °C per day in a pyrolysis temperature range, wherein the pyrolysis temperature range is from about 270 °C to about 400 °C; and

producing a mixture from the formation.

5442. (new) The method of claim 5441, further comprising controlling formation conditions, wherein controlling formation conditions comprises maintaining a temperature in the part of the formation in the pyrolysis temperature range, wherein the pyrolysis temperature range is from about 270 °C to about 400 °C.

5443. (new) The method of claim 5441, wherein at least one of the heaters comprises a natural distributed combustor.

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5444. (new) The method of claim 5441, wherein providing heat from the one or more heaters to at least the portion of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

5445. (new) The method of claim 5441, wherein allowing heat to transfer from the one or more heaters increases a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

5446. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5447. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

5448. (new) The method of claim 5441, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

5449. (new) The method of claim 5441, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5450. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5451. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5452. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5453. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable

hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5454. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5455. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5456. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5457. (new) The method of claim 5441, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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5458. (new) The method of claim 5441, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

5459. (new) The method of claim 5441, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5460. (new) The method of claim 5441, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5461. (new) A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer substantially by conduction from the one or more heaters to a part of the formation;
controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute; and
producing a mixture from the formation.

5462. (new) The method of claim 5461, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

5463. (new) The method of claim 5461, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

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5464. (new) The method of claim 5461, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5465. (new) The method of claim 5461, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5466. (new) The method of claim 5461, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that a permeability of the majority of

the part of the formation is substantially uniform.

5467. (new) The method of claim 5461, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5468. (new) The method of claim 5461, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5469. (new) The method of claim 5461, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

5470. (new) The method of claim 5461, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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5471. (new) A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer from the one or more heaters to a part of the formation;
controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute;
producing a mixture from the formation; and
wherein the mixture comprises H₂, and wherein the partial pressure of the H₂ is measured when the mixture is at a production well.

5472. (new) The method of claim 5471, further comprising controlling formation conditions, wherein controlling formation conditions comprises maintaining a temperature in the part of the

formation in the pyrolysis temperature range, wherein the pyrolysis temperature range is from about 270 °C to about 400 °C.

5473. (new) The method of claim 5471, wherein at least one of the heaters comprises a natural distributed combustor.

5474. (new) The method of claim 5471, wherein providing heat from the one or more heaters to at least the portion of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

5475. (new) The method of claim 5471, wherein allowing heat to transfer from the one or more heaters increases a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

5476. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

E4 5477. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

5478. (new) The method of claim 5471, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

5479. (new) The method of claim 5471, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5480. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5481. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5482. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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5483. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5484. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5485. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5486. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5487. (new) The method of claim 5471, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5488. (new) The method of claim 5471, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

5489. (new) The method of claim 5471, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

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5490. (new) The method of claim 5471, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5491. (new) A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer from the one or more heaters to a part of the formation;
controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute;
producing a mixture comprising molecular hydrogen from the formation; and
recirculating a portion of the molecular hydrogen from the mixture into the formation.

5492. (new) The method of claim 5491, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

5493. (new) The method of claim 5491, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5494. (new) The method of claim 5491, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5495. (new) The method of claim 5491, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5496. (new) The method of claim 5491, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that a permeability of the majority of the part of the formation is substantially uniform.

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5497. (new) The method of claim 5491, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5498. (new) The method of claim 5491, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5499. (new) The method of claim 5491, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

5500. (new) The method of claim 5491, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

5501. (new) A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer from the one or more heaters to a part of the formation;
controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute;
providing hydrogen (H_2) to the part of the formation to hydrogenate hydrocarbons in the part of the formation;
heating a portion of the part of the formation with heat from hydrogenation; and
producing a mixture from the formation.

5502. (new) The method of claim 5501, further comprising controlling formation conditions, wherein controlling formation conditions comprises maintaining a temperature in the part of the formation in the pyrolysis temperature range, wherein the pyrolysis temperature range is from about 270 °C to about 400 °C.

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5503. (new) The method of claim 5501, wherein at least one of the heaters comprises a natural distributed combustor.

5504. (new) The method of claim 5501, wherein providing heat from the one or more heaters to at least the portion of the formation comprises:
heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (*Pwr*) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (*h*) of the selected volume is about 10 °C/day.

5505. (new) The method of claim 5501, wherein allowing heat to transfer from the one or more heaters increases a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

5506. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5507. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

5508. (new) The method of claim 5501, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

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5509. (new) The method of claim 5501, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5510. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5511. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5512. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5513. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5514. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5515. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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~~5516. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.~~

5517. (new) The method of claim 5501, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5518. (new) The method of claim 5501, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the

molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

5519. (new) The method of claim 5501, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5520. (new) The method of claim 5501, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5521. (new) The method of claim 5501, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

5522. (new) The method of claim 5501, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5523. (new) The method of claim 5501, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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5524. (new) The method of claim 5501, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5525. (new) The method of claim 5501, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that a permeability of the majority of the part of the formation is substantially uniform.

5526. (new) The method of claim 5501, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5527. (new) The method of claim 5501, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5528. (new) The method of claim 5501, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

Response To Office Action Mailed June 5, 2003

A. Pending Claims

Claims 531, 533-537, 539, 541-556, 558, 560, 563-609, 5396, 5397, and 5400-5403 are currently pending. Claims 531, 539, and 541 have been amended. Claims 539 and 541 have been amended for clarification and/or correction of typographical errors. Claims 532, 538, 540, 559, 561, 562, 610, 623-625, 665-706, 5398, and 5404-5440 have been cancelled. Applicant requests entry of new claims 5441-5528.

B. Provisional Double Patenting Rejection

The Examiner provisionally rejected claims 531-556, 558-609, 5396, 5397, and 5400-5403 under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims of copending applications. The Examiner specifically provisionally rejected claims 531-556, 558-609, 5396, 5397, and 5400-5403 under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 532-569 and 571-609 of copending U.S. Patent Application No. 09/841,430. Upon issuance of a patent for U.S. Patent Application No. 09/841,430 or the present application, or upon the applications being

in condition for allowance but for the provisional double patenting rejection, Applicant will provide arguments for the inappropriateness of the double patenting rejection and/or provide a terminal disclaimer for the patent and/or patent applications.

C. The Claims Are Not Anticipated By Or Obvious Over Elkins

The Examiner rejected claims 531, 533, 534, 542-553, 555, 556, and 564-566 under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over U.S. Patent No. 2,734,579 to Elkins (hereinafter “Elkins”). The Examiner rejected claims 539 and 541 under 35 U.S.C. 103(a) as being unpatentable over Elkins. The Examiner rejected claims 568 and 569 under 35 U.S.C. 103(a) as being unpatentable over Elkins, as applied to claim 531, and further in view of U.S. Patent No. 2,914,309 to Salomonsson or U.S. Patent No. 4,067,390 to Camacho et al. Applicant respectfully disagrees with these rejections.

In Item 10 of the office Action, the Examiner stated: “It is noted that claims 532, 537, 540, 554, 558, 559-563, 567, 570-609, 5396, 5397 and 5400-5403 have been rejected only on the grounds of double patenting.” Claim 531 has been amended to include features of claim 532. Applicant respectfully requests removal of the rejection of claim 531 and the claims dependent thereon.

D. New Claims

The Examiner noted that claims 538, 540, 559, 561, and 562 have been rejected only on the grounds of double patenting.

New claim 5441 includes features of claim 538 written in independent form. New claim 5461 includes features of claim 540 written in independent form. New claim 5471 includes features of claim 559 written in independent form. New claim 5491 includes features of claim 561 written in independent form. New claim 5501 includes features of claim 562 written in independent form. Claims dependent on new claims 5441, 5461, 5471, 5491, and 5501 are